Proper Removal of Soluble Salts After Detecting Their Presence

--Prevent Premature Coating Failures

--Enhance Straightforward Maintenance Procedures

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Report Documentation Page

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- ***Awareness***
- ***Recognition***
- ***Elimination***

Objective: ***Reduce liability of premature coating failure from corrosion***

Goal: ***Achieve full life cycle coating performance***

Reality Check

- "Prior to 1995, it is estimated that at least 3 out of 4 contractors suffered major failures during projects or shortly thereafter. Most coatings did not survive more than 5 to 7 years. Now with changes, **including (*soluble salt remover*), we have an approximately 70 to 90% reduction in lifecycle costs, have reduced premature coating failures and increased service life.**"

Non vendor specific edit

What are Soluble Salts?

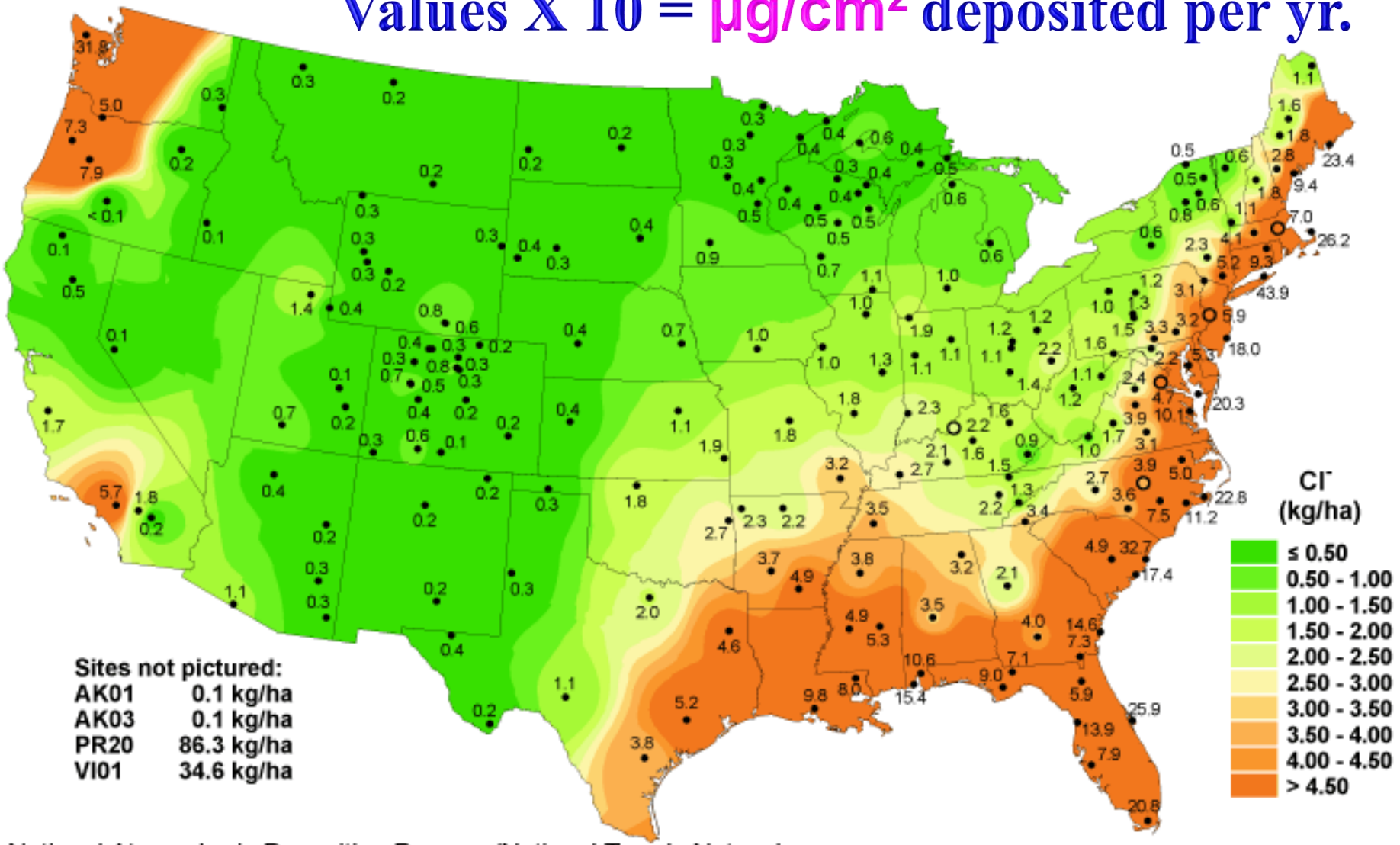
- Ionic ***contaminants***
- ***Water soluble*** inorganic compounds
- Primarily ***chlorides, sulfates, and nitrates***
- ***Non-visible*** contaminants
- Can bond ***electrochemically*** to the metal substrate

Sources

- Marine bodies (sea water-chlorides)
- De-icing salts (chlorides)
- Acid rain (sulfates/nitrates):
  - Stack gases
  - Auto/vehicle emissions
- Chemical processes (many combinations of salts)
- Water and sewage treatment facilities
- Lightning
- Abrasives (chlorides/sulfates)

Chloride ion wet deposition, 2008

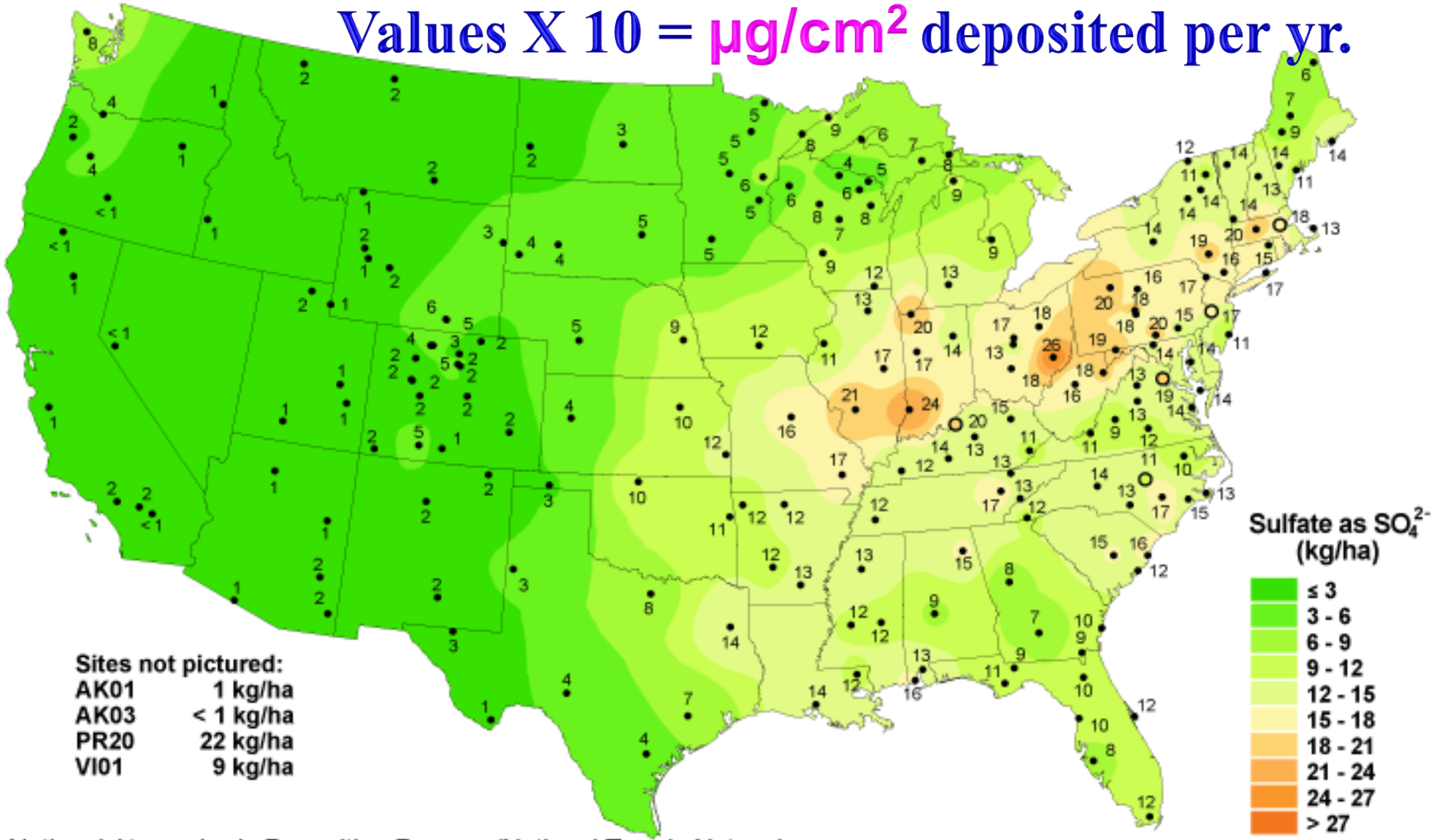
Values X 10 = µg/cm^2 deposited per yr.



National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu

Sulfate ion wet deposition, 2008

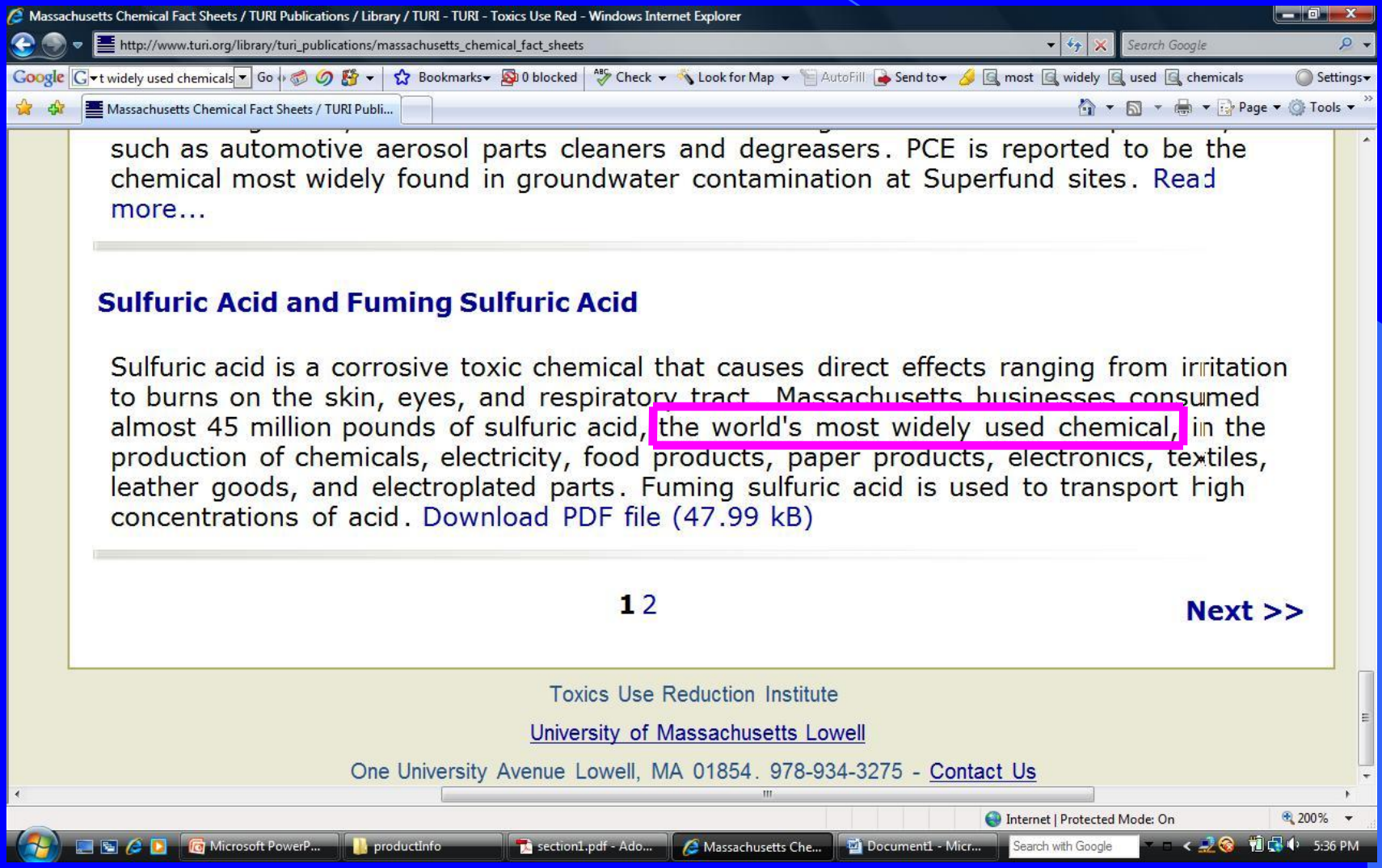
Values X 10 = µg/cm^2 deposited per yr.



National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu

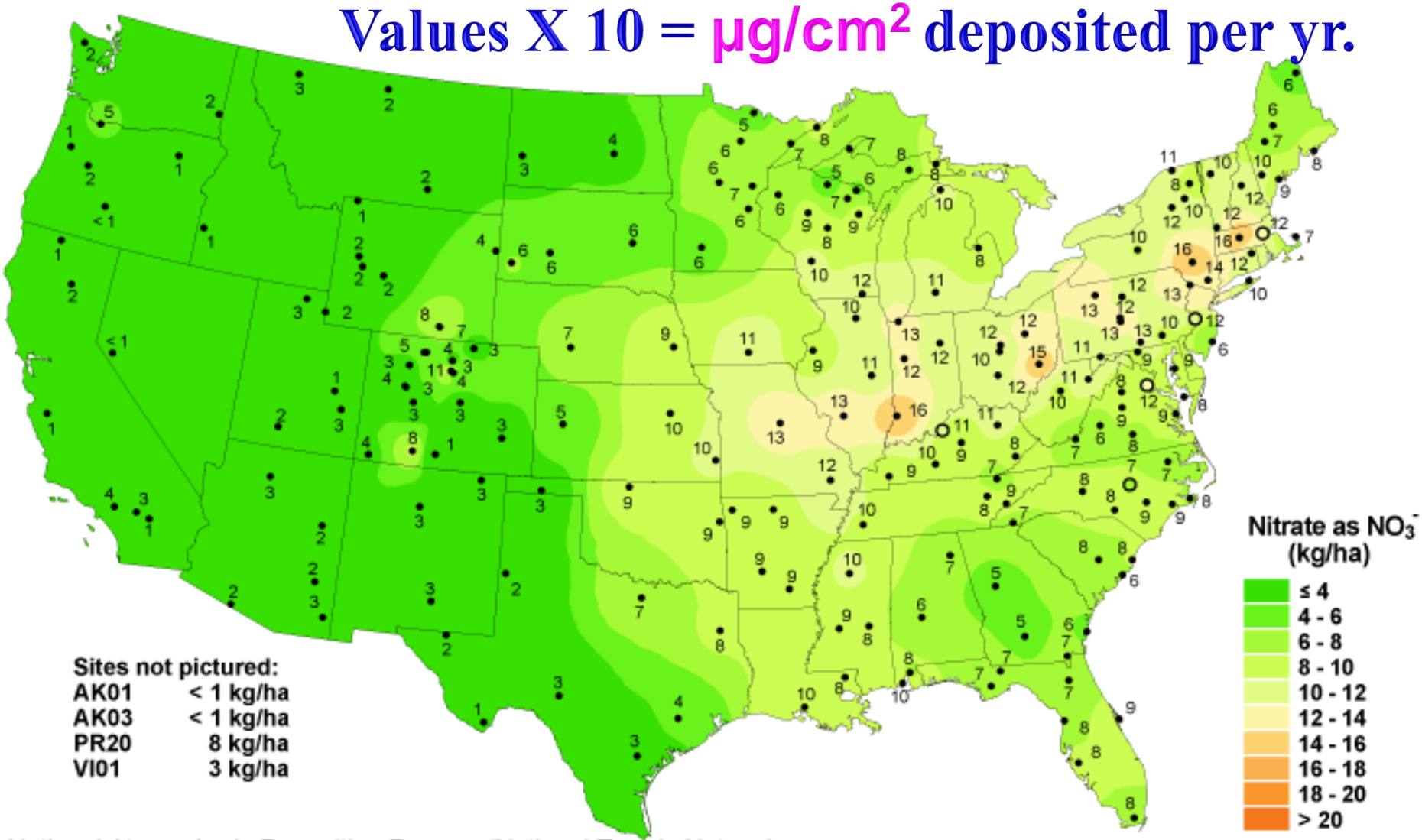
Sulfuric Acid Reigns Supreme

http://www.turi.org/library/turi_publications/massachusetts_chemical_fact_sheets



Nitrate ion wet deposition, 2008

Values X 10 = µg/cm^2 deposited per yr.



National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu

Non-visible

- Visually clean substrates are not adequate
- Soluble salts require testing to be detected
- Which salt is the problem? - Primarily dependent on service environment

Microgram per square centimeter

- Pinky fingerprint approximates 1 square centimeter

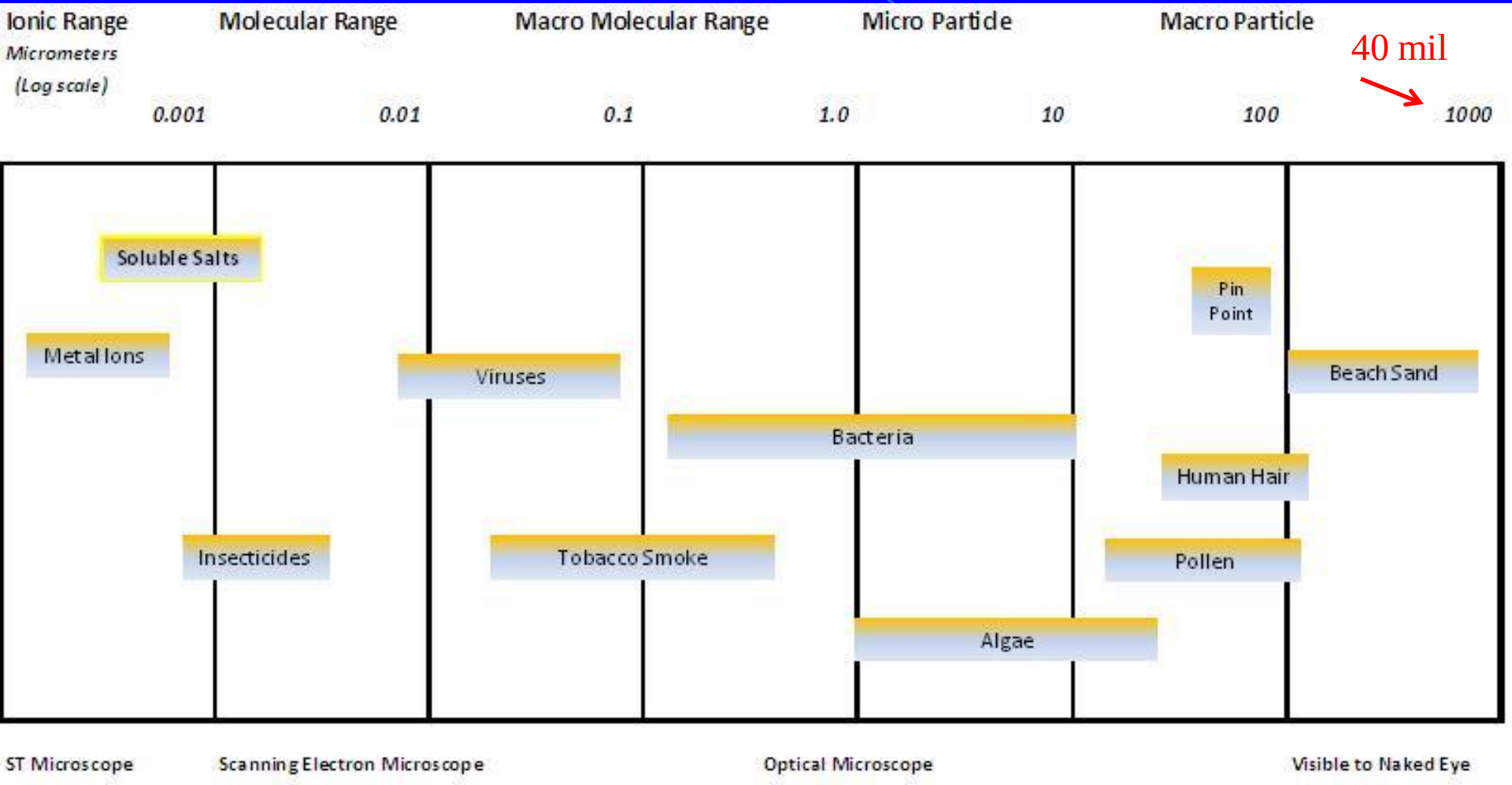
- M&M candy sliced into ***one million pieces***
  --single slice = <u>1 microgram</u>

- Salt packet from McDonalds for fries
  --disolved in water
  --then spread over 1,000 sq ft would **deposit**

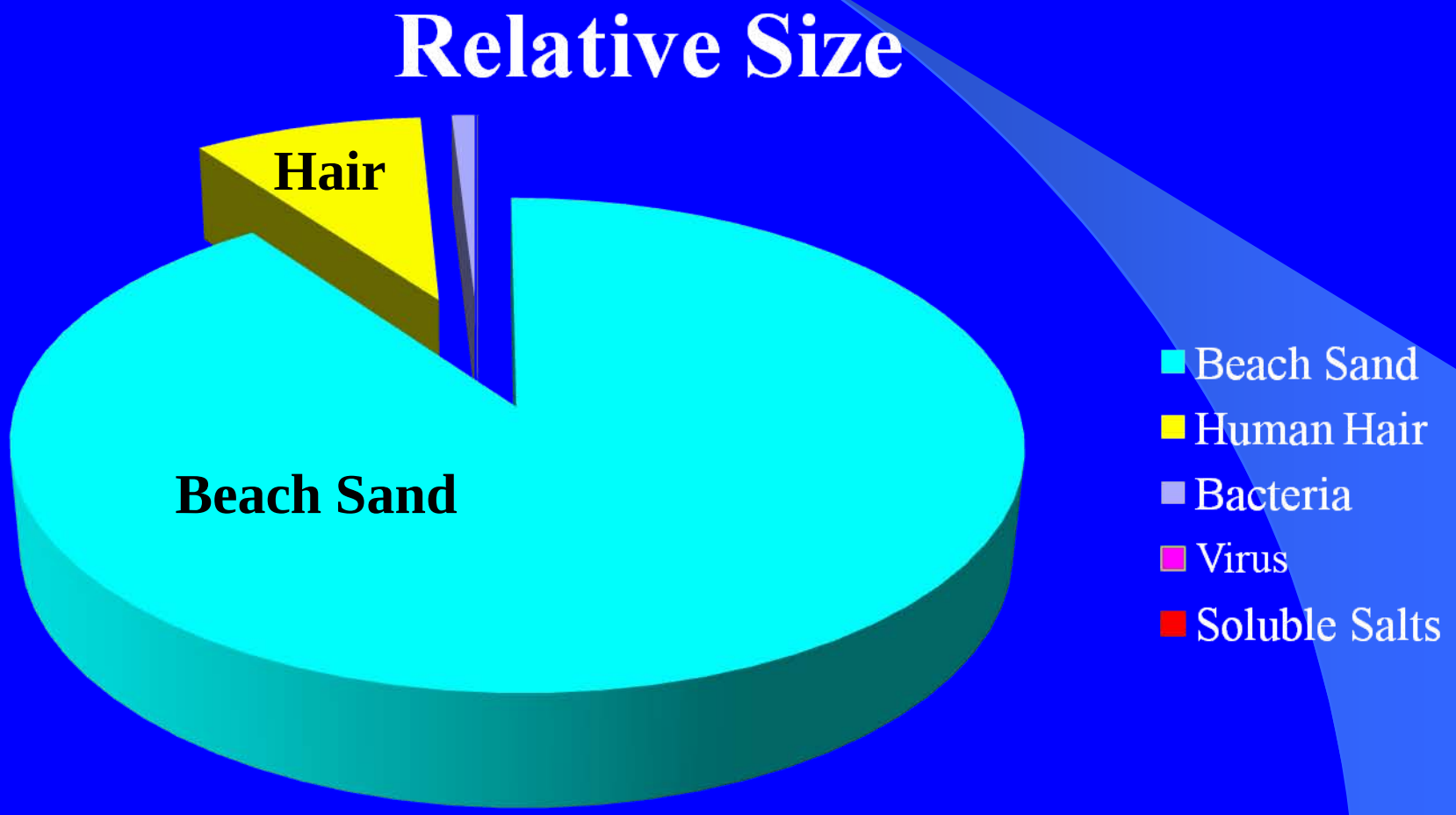
<u>1 microgram per square centimeter</u>

µg/cm^2

Relative Size Chart



Perspective -- Sizing



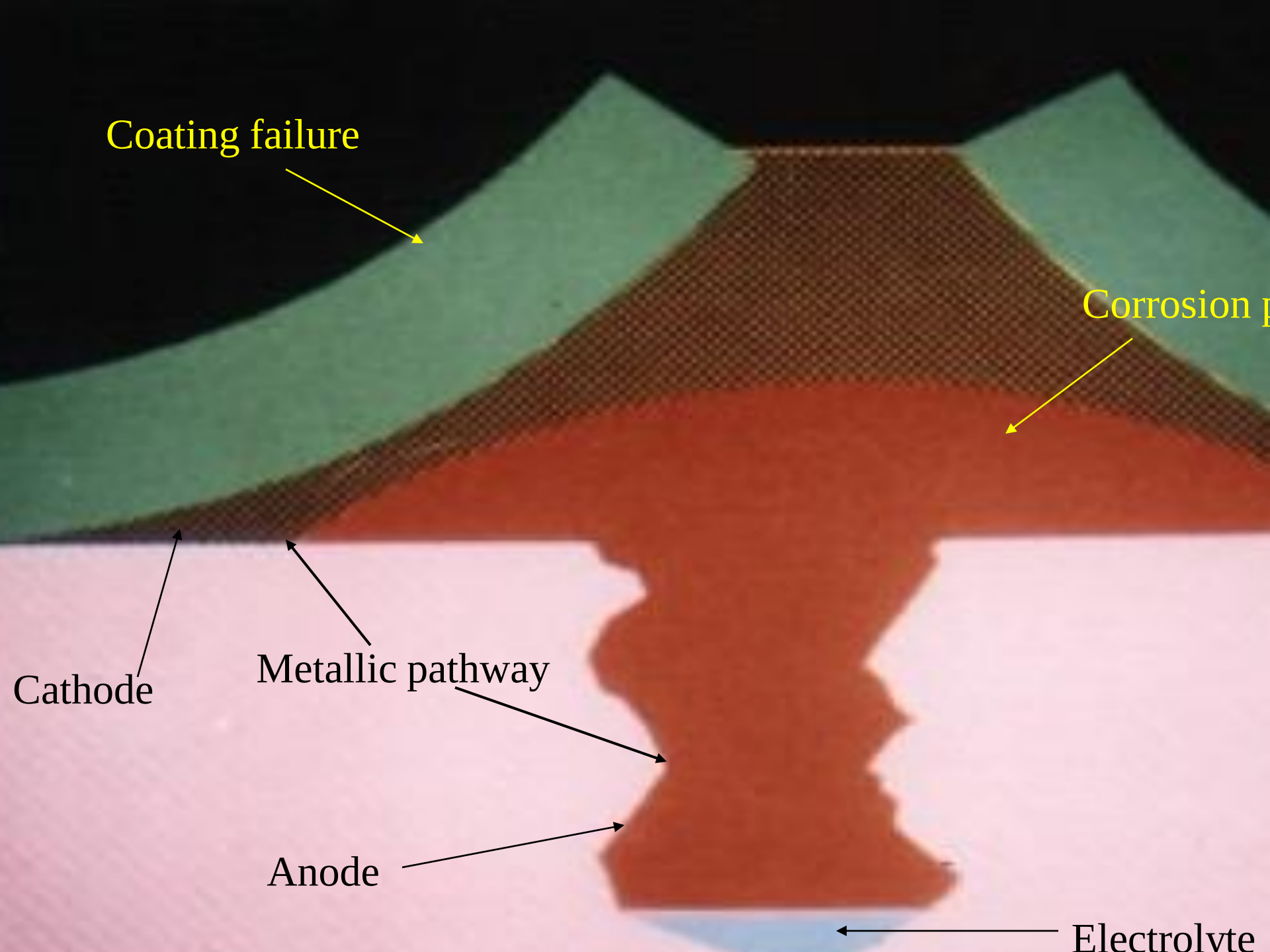
Detrimental Effects of Salts

- Interferes with adhesion
- Accelerates corrosion
- Causes blistering of coatings

Corrosion Cell

- A corrosion cell consists of 4 components

- An anode (“-” provided by steel itself)
- A cathode (“+” provided by steel itself)
- A metallic pathway (provided by steel itself)
- An electrolyte (**salt** + moisture = electrolyte)


Coating failure
Corrosion p
Cathode
Metallic pathway
Anode
Electrolyte

Electrolyte—the **ONE and ONLY** variable we ***can control is…***

- Salts are hygroscopic = Draw moisture
- All liquid applied coatings are permeable and salts will draw moisture through the coating film, thereby providing the electrolyte needed for corrosion activity
- Some coatings are less permeable than others

Osmotic Blisters

- The same hygroscopic action which causes corrosion also causes osmotic blistering
- The hygroscopic action of salts builds up pressure within a blister which can exceed the bond strength of the coating

Salt Corrosion Cycle

Iron +Salt + Moisture = RUST + Acid

$$Fe + 2H^{+} \rightarrow Fe^{+2} + H_2\uparrow$$

$$Fe^{+2} + O_2 + 4H^{+} \rightarrow Fe^{+3} + 2H_2O$$

$$Fe^{+3} + 3Cl^{-} \rightarrow FeCl_3$$

$$2FeCl_3 + 3H_2O \rightarrow Fe_2O_3 + 6HCl$$

Without remediation, repeat reaction cycle

Analysis methods

Two distinct methods:

- Conductivity – measures all conductive constituents.
- Ion specific – measures the specific ion of concern; chloride, sulfate, or nitrate.

Conductivity Method

- Measures everything conductive in the sample.
- Many species are not detrimental to the coating film nor induce premature coating failure.
- Measures all minerals.
- Conversion to chloride level is an estimate.
  - Assumes a lab correlation based on 100% chlorides.
  - Conductivity and reactivity are different.

Detecting Soluble Salts

- **Extraction methods**
  - Swabbing (DI water) [25 – 35%]
  - Patch Cell (DI water) [45 – 60%]
  - Wet filter paper (DI water) [??]
  - Magnetic cell (DI water) [45 – 60%]
  - Sleeve method (proprietary acid solution) [80%]
  - Boiling (lab; destructive field sample) [90 – 95%]
- **Quantitative analysis**

(Sources: SSPC TU4; Third party laboratories)

Chloride Analysis by Ion Detection Tubes

- Sealed ampoule, break both ends and immerse in extract solution
- Cl^- read from calibrated tube in PPM and micrograms per square centimeter
- ISO 8502-5

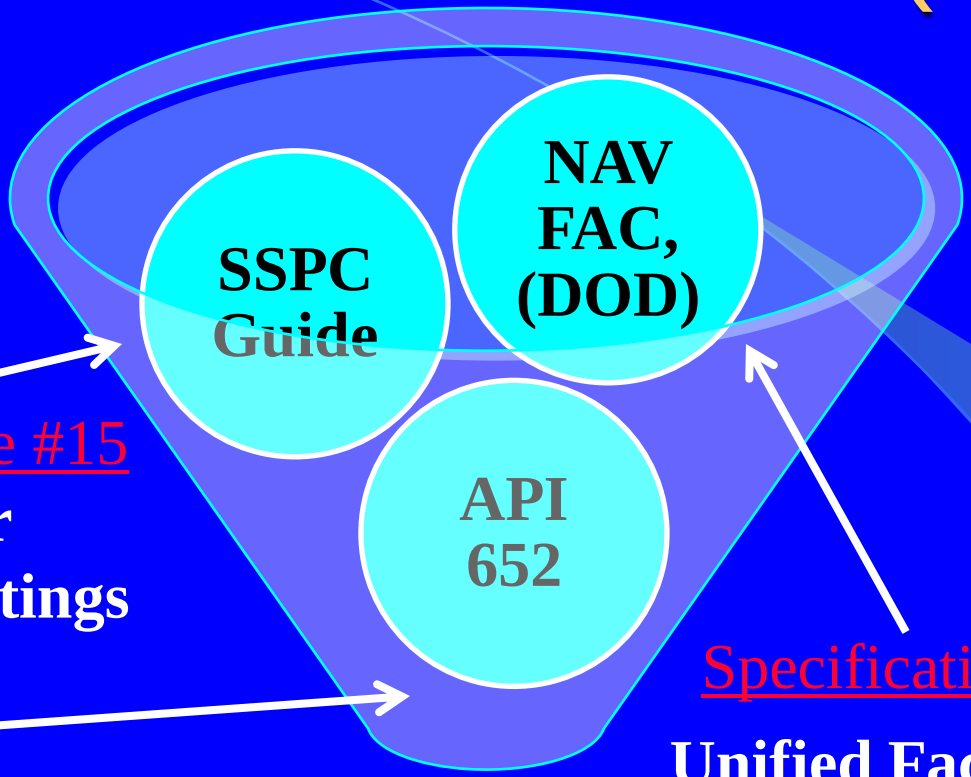
Analysis of Sulfate

- ***Electronic turbidity method***
  - ***Add barium chloride to extract solution to form $BaSO_4$***
  - ***Measure absorbency/transmittance***
- ***New Field Test Kit***
- ***ISO 8502-11***
  - ***Maryland Bridge***
  - ***I-95 Delaware***
  - ***Casciano Bridge near Newark A/P***

Analysis for Nitrates

- Dip pillow end of nitrate strip into extracted solution for 2 seconds
- Wait 1 minute and compare color on pillow to color on comparator card
  - ***NASA Gantry***
  - ***St. Lawrence Seaway***

BEST PRACTICES (BMP)



Technical Guide #15
The Society for Protective Coatings

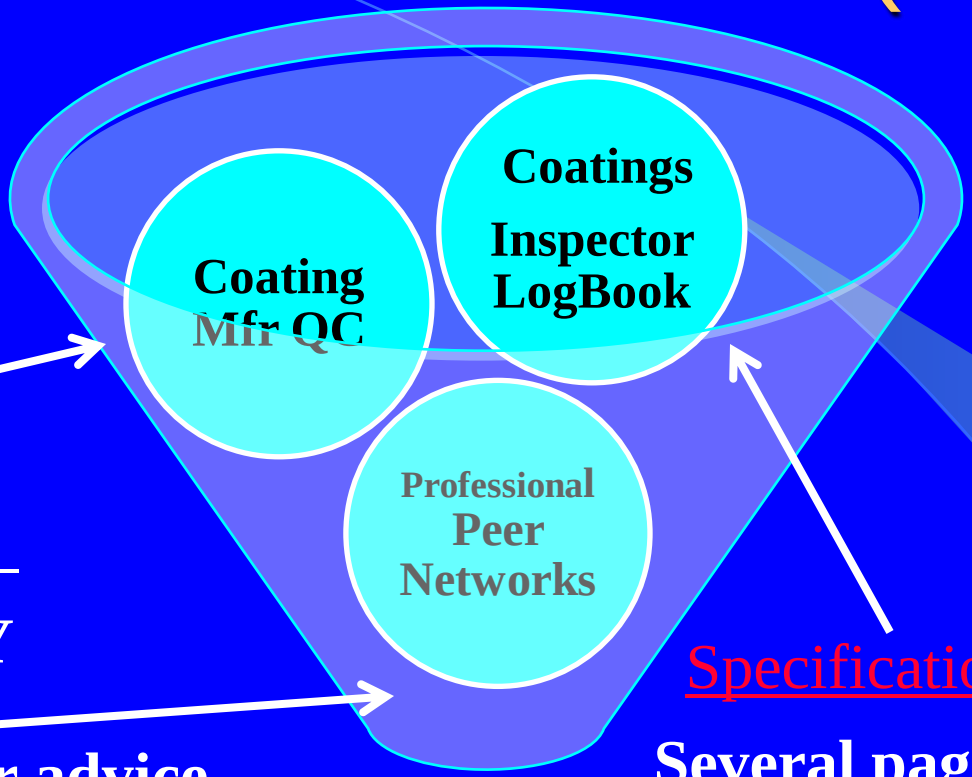
Draft Version
American Petroleum Institute

Specification
Unified Facilities Guide Specifications

Extended Performance

Societies

BEST PRACTICES (BMP)



Quality Control
Called in specs—
Warranty ONLY

Repeated mentor advice to test for salts rather than risk fiasco

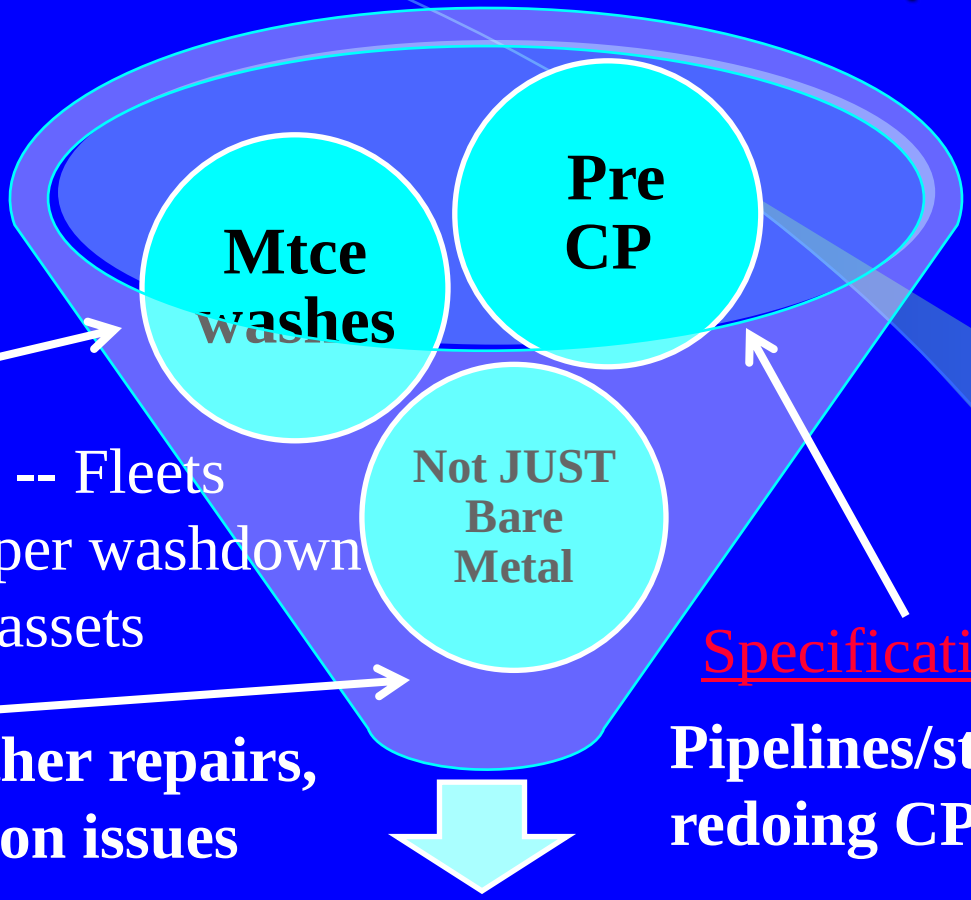
Specification

Several pages address similar to Dewpoint, RH, Temp. KEY Criteria

Extended Performance

QC Caring

BEST PRACTICES (BMP)



Quality Control -- Fleets & Structures proper washdown should not harm assets

Concrete and other repairs, intercoat adhesion issues

Specification

Pipelines/structures when redoing CP clean properly

Extended Performance

In Service/Field

NAVSEA: 009-32 Standard Item

- Chloride limit: 3 µg/cm^2 immersion.
- FY-10: Water wash to meet the limit after abrasive blast.
  - Can require multiple washes.
- FY-11 (Prelim): Allows the use of an approved salt remover.
  - Approval via the F718 from the coating manufacturer

ONR funded research at Carderock and CTC, Johnstown support efficacy and acceptability of ***an established and time tested soluble salt remover***.

Surface Preparation Issue

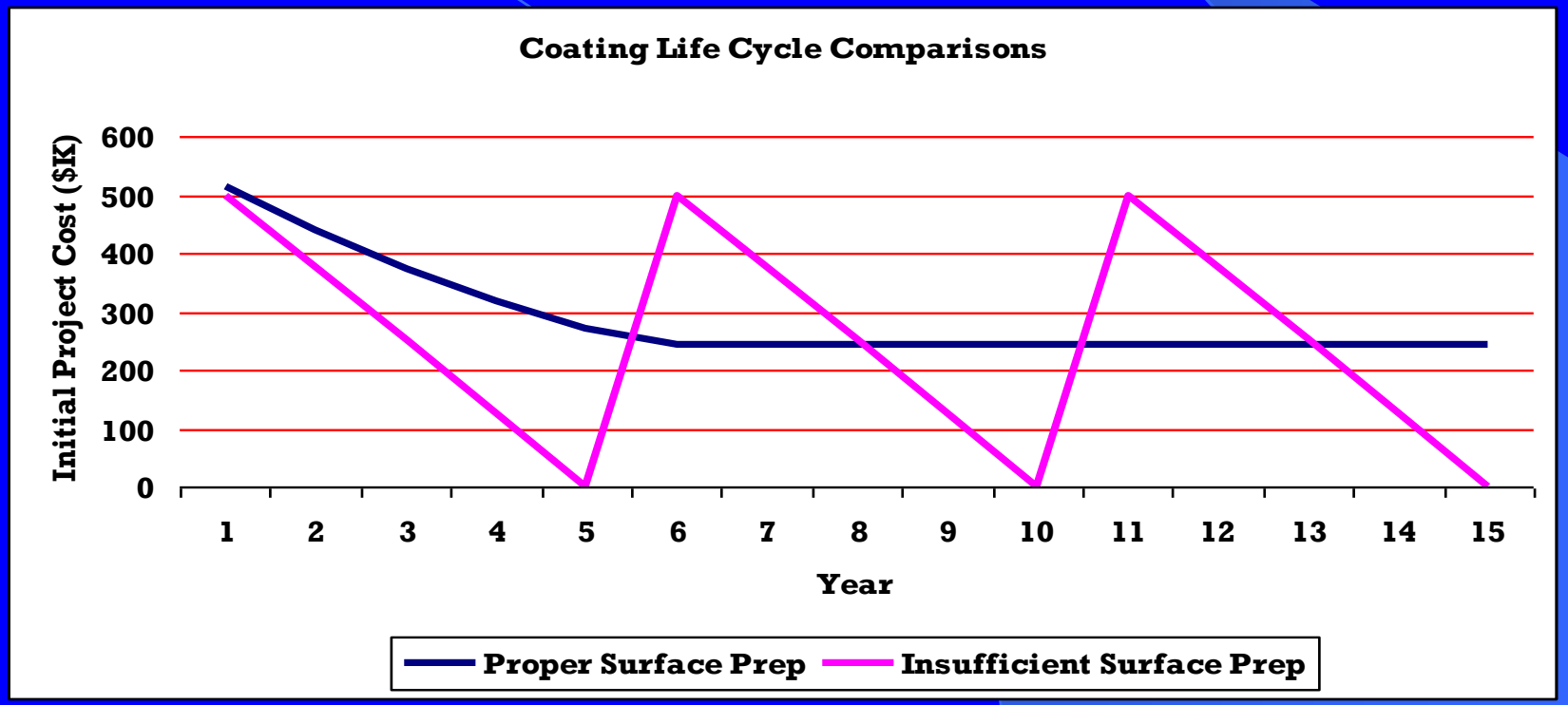
- Industry standards are generally visual.
- Present coatings cannot tolerate salts.
- Non-visible contaminants are getting more attention.
- Soluble salt removal is critical to coating life cycle performance.

Coatings Economics

Goal: Achieve lowest cost/ft^2/yr for the expect coating life

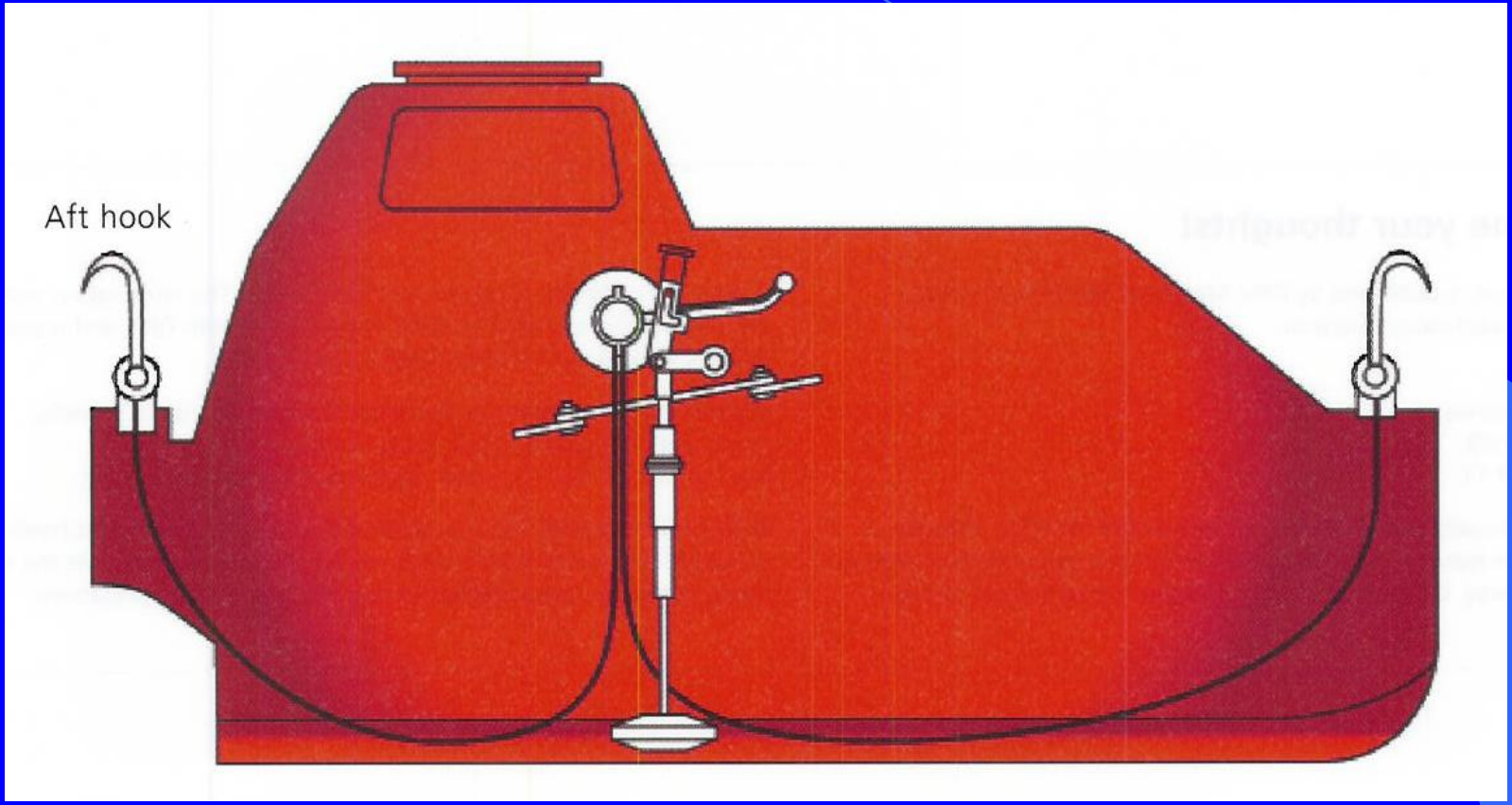
Total Surface Area:	90,000 ft^2	Service: Tank Lining
Insufficient Surface Prep:	$500,000	5 yr coating cycle
Proper Surface Prep:	$515,000	15 yr coating cycle

Cost/ft^2/yr (today's $):	Cost /yr over 15 yrs
Insufficient Surface Prep:	$1.11/ft^2/yr
Proper Surface Prep:	$0.38/ft^2/yr



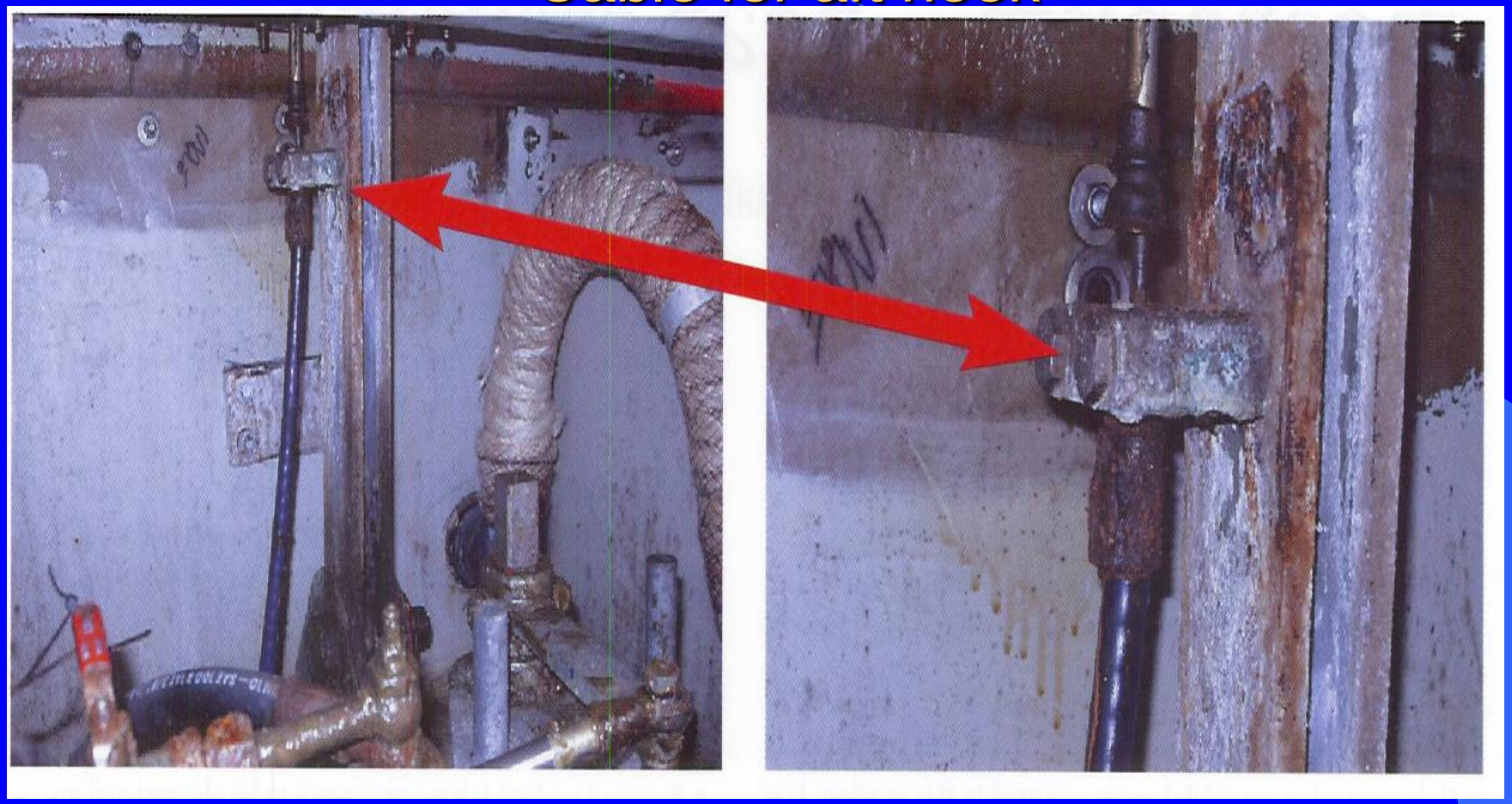
Based on actual experience by NAVFAC since instituting revised specifications in 1995.

Enclosed Lifeboat



PRIOR VIDEO and these next 5 slides courtesy of US Coast Guard

Cable for aft hook



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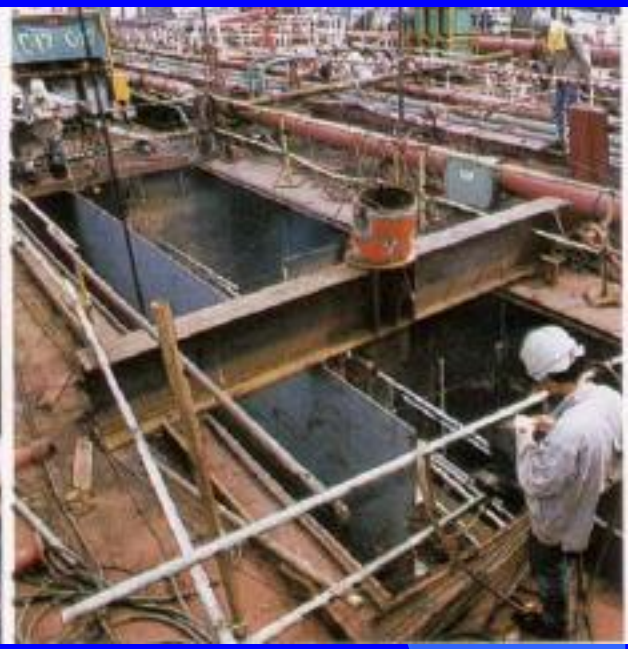
Case 1

Type: Crude Oil Tanker **DWT:** 135,000

Age Of Vessel : 16 Years,

Total Steel replacement : **1,200 Metric Tonnes**

Case # 1..



Renewals were carried out on various internal structures in Cargo & Ballast tanks including areas on the bottom plating

PRIOR VIDEO and these next 5 slides courtesy of US Coast Guard

Case 1

Case 1.. Cont'd..

The renewal Process on the Ship....

The Final Product

Arrival Condition

PRIOR VIDEO and these next 5 slides courtesy of US Coast Guard

Case 2

Case 2..

Type: Oil Tanker , DWT: 108,628 **Age Of Vessel :** 15 Years,

Total Steel renewal was : **150 T .. And steel renewal was Limited only to Ballast tank areas…**

What happened : Case # 1 = 1200 Tonnes and Case # 2 = 150 Tonnes.

Reason :

The Ship owner in Case # 2 did better Preventive Maintenance during her trading Years!!

PRIOR VIDEO and these next 5 slides courtesy of US Coast Guard

The B-307 was flown to Dulles in 2003 for delivery to the Smithsonian

Boeing Removes Corrosion Inducing Salts from Ditched Aircraft

Repairs:

Salt removal during Surface Preparation

Why?

- ✓ Salts are a leading cause of coating failure today.
  - ✓ ~80% of coating failures due to salts
- ✓ Visual standards used are insufficient.
- ✓ Visual standards **were** adequate for lead paint applications.

Rusty Ammo Magazine

Rusty Ammo Magazine

Soluble Salt Analysis and Removal Products Must Be:

- Proven
- Efficient
- Improve Adhesion
- Assist in removal of surface oils
- Cost effective
- Safe
- Easy to use
- Environmentally friendly